Psychosocial outcomes at three and nine months after good neurological recovery from aneurysmal subarachnoid haemorrhage: predictors and prognosis

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Objectives: To investigate (1) the prevalence of various aspects of cognitive and psychosocial dysfunction, including post-traumatic stress symptoms, over nine months after subarachnoid haemorrhage (SAH); (2) whether SAH is preceded by increased life stress; (3) to what extent adverse outcomes may be predicted from preillness life stress, early neurological impairment, age, and sex; and (4) relations between emotional and functional outcomes.

Methods: 52 patients with good neurological recovery after surgery for SAH were each matched for age, sex, and occupation with a healthy control participant. SAH patients were assessed three and nine months postdischarge on measures of cognitive functioning, mood, and social functioning. Objective stressors and subjective life change during the preceding year were rated retrospectively. Controls completed measures of mood and social functioning once only.

Results: Compared with controls, SAH patients showed increased mood disturbance, subtle cognitive impairment, and abnormally low independence and participation on measures of social functioning. 60% showed clinically significant post-traumatic stress symptomatology (intrusive thoughts or avoidance of reminders) at three months and 30% at nine months. Independence in activities of daily living was greatly reduced in half to a third of the sample at both three and nine months. Productive employment was below the 10th percentile of the control group for 75% of patients at three months and for 56% at nine months; this outcome could not be predicted from selected demographic, premorbid, or clinical variables but dependence on others for organisational activities was predicted by impaired prose recall. Mood at nine months was strongly predicted by prior mental health problems, poor physical health, dysphasia, and impaired prose recall at three months. There was no evidence of an abnormally high level of stressful life events in the year before SAH, although patients rated their subjective level of stress in this period slightly more highly than did the control participants.

Conclusions: These findings highlight the need for structured support and treatment after surgery for SAH to reduce persisting mood disturbance and increase independence and participation.

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A number of studies following up patients who have survived aneurysmal subarachnoid haemorrhage (SAH) have noted relatively high rates of psychological distress and impaired social functioning even in those making a good neurological recovery.^{1–9} Neuropsychologically, a subgroup of these patients show cognitive impairments particularly affecting verbal recall and measures of executive function; indeed, Sonesson *et al*¹⁰ found some cognitive impairment in all but one of a series of 93 neurologically recovered patients, while other studies have reported similar deficits in smaller subgroups.^{11–12} Although the impairments may be mild, Vilkki *et al*¹ observed a significant association with reduced employment status following the illness. As yet it has not been possible to identify clinical features of SAH (for example, site of aneurysm, vasospasm, operative leakage, or temporary vessel occlusion) that consistently predict whether a patient will manifest cognitive impairment.^{13–15} However, there is a growing consensus that a sizeable proportion of patients have little or no cognitive impairment in the long term.^{16–17}

In contrast, emotional distress and a reduction in social independence are much more common sequelae up to five years after surgery. This is clearly true for patients with severe SAH and whose neurological impairments are sufficiently severe to merit inpatient rehabilitation^{18–19}; however, an early study by Freckmann *et al*³ noted high rates of mood disturbance and loss of social contact in patients with good physical and cognitive outcomes, while Beristain *et al*⁶ also

reported high rates of anxiety and depression. These observations have more recently been replicated in studies by Mangold and Wallenfang⁸ and Buchanan *et al*⁹: the latter group found that the majority of a sample of 28 patients reported adverse changes in mood, employment, energy levels, tolerance of mild stressors, leisure activities, and social and sexual relations. In a larger sample of 89 patients with good neurological outcomes, Ogden *et al*² found that a year after surgery 86% continued to experience high levels of fatigue while 59% of those who had been employed before their illness had not resumed their previous level of work. Likewise, Hutter⁷ found that between 30 and 45% of a similar group of patients suffered from loss of motivation, abnormal introversion, emotional lability, and strain. Reduced employment rates are frequently noted^{4–5} and disturbances of interpersonal relationships have been a significant concern.^{1–9} In a review of this literature, Politynska *et al*²⁰ conclude that, depending on the sensitivity of the measures used, somewhere between a third and half of patients have neuropsychiatric or psychosocial

Abbreviations: BDI, Beck depression inventory; BICRO-39, brain injury community rehabilitation outcome-39; COWAT, controlled oral word association test; GOS, Glasgow outcome scale; HADS, hospital anxiety and depression scale; LCS, life change scale; MANOVA, multivariate analyses of variance; PTSD, post-traumatic stress disorder; RIES, revised impact of events scale; RLCQ, revised life changes questionnaire; SAH, subarachnoid haemorrhage

problems. Nevertheless, a subgroup of patients apparently make a complete psychosocial recovery; for example, Hop *et al*²¹ found that patients with no neurological symptoms at all reported no reduction in quality of life.

Explanations for the observed psychosocial problems vary. It has been argued that organic brain injury resulting either from the bleeding itself or from lesions caused surgically is likely to give rise to neuropsychological impairments that either directly or indirectly underlie the observed mood changes and functional problems.^{16–22–23} However, Ogden *et al*²⁴ found that patients who had suffered a SAH were much more likely than orthopaedic or spinal patients to have experienced a high rate of stressful life events in the year preceding the bleeding. They have suggested that stress is a predisposing factor for SAH, raising the possibility that at least some of the psychosocial problems manifesting after SAH may have been present before it occurred. The majority of studies reviewed above were cross sectional, without non-neurological comparison groups, and involved retrospective interviews at variable time periods after the SAH; they are consequently unable to distinguish between these two possible explanations.

McKenna *et al*²⁵ conducted one of the very few prospective follow up studies comparing SAH patients with an appropriate comparison group. They assessed 100 patients consecutively admitted to a neurosurgical unit at the point of discharge and again 12 months later, using neuropsychological tests and a semistructured interview with patients and their close relatives concerning various aspects of quality of life. Their data were compared with those of patients who had suffered a myocardial infarction to clarify whether non-specific factors associated with acute life threatening illness can explain any post-SAH dysfunction. "Quality of life" was found to be compromised in about half of both patient groups, leading the authors to conclude that the psychosocial problems found in SAH patients probably reflect a combination of normal rates of psychological morbidity in people of this age range and non-specific sequelae of life threatening illness rather than organic brain injury. Interestingly, there has been little exploration of possible post-traumatic stress reactions after SAH, with only one single case report identifying such symptomatology²⁶ though it is a recognised problem after stroke.²⁷

However, the study of McKenna *et al*²⁵ was limited by its use of qualitative and rather gross measures of psychosocial functioning. Thus, employment, home life, social life, and emotional functioning were categorised by the interviewer simply as impaired or not impaired. This may have led to underreporting of changes; for example, only 33% of the patients without neurological impairment were categorised as having adverse emotional changes, an estimate that contrasts with the results of more recent studies that have used better validated and quantitative assessment methods. Thus, Beristain *et al*,⁶ using the Beck depression inventory (BDI),²⁸ found clinical levels of depression in 75% of patients. In a prospective study conducted by Maurice-Williams *et al*,²⁹ residual psychological symptoms were reported by 60% of a group of SAH patients a year after making a good neurological recovery from surgery.

On the balance of the evidence, it seems probable that psychosocial problems following SAH are likely to reflect interactions between organic impairments, pre-existing life stressors, changes in social circumstances, or the occurrence of other stressors (such as reduced employment or lowered income) following the injury and non-specific reactions to life threatening illness. While it is of theoretical interest to ascertain the extent to which problems are direct organic effects of the brain injury, these possible causal factors are so interconnected that the question is unlikely to be answerable with precision. From a clinical standpoint, where the aim is to minimise the adverse outcomes of SAH, the more germane question is the extent to which psychosocial problems can be accurately depicted, predicted, and remediated. If it is possible

to identify which patients are most likely to suffer functional or psychological problems in the long term, the psychological interventions could be targeted at these patients at an early stage to prevent or reduce the escalation of secondary consequences. The present study therefore sought (1) to define the prevalence of various aspects of cognitive and psychosocial dysfunction, including post-traumatic stress symptomatology, over nine months following SAH using sensitive and valid quantitative indices; (2) to see whether the finding of Ogden *et al*²⁴ that life stress increases in the year preceding SAH is replicable; (3) to ascertain to what extent adverse emotional and functional outcomes may be predicted from measures of preillness life stress, severity of early neurological impairment, age, and sex; and (4) to explore relations between emotional and functional outcomes.

METHODS

Design

This was a prospective study in which 52 consecutive patients admitted to the neurovascular service of the National Hospital for Neurology and Neurosurgery, London, UK for treatment of aneurysmal SAH who were making a good neurological recovery were interviewed at discharge from hospital and then again at three and nine months after discharge. They completed a range of neuropsychological assessments and quantitative measures of various aspects of psychosocial functioning at each point. Where possible, their partner or a close friend or relative was also interviewed. Ethical approval for the study was given by the hospital's ethics committee.

For each participant a healthy control subject of the same sex and closely matched for age and occupational status (by job title where possible; for example, teacher, secretary, porter) was found from within the general population through personal contacts and advertisement. The healthy control participants completed several of the self report questionnaires assessing aspects of psychosocial function, so that the scores of the SAH participants could be compared with those of a demographically equivalent sample rather than only with the restricted normative data available for many of these measures. The controls were not, however, assessed on the cognitive measures; the scores of the SAH patients were instead compared with existing age related norms.

SAH participants

Patients were eligible if they were aged 16 or over, had a good initial World Federation of Neurosurgical Societies grade (I or II), and had made a good neurological recovery at the point of hospital discharge (Glasgow outcome scale (GOS) score of 4 or 5). All participants were approached and had the study explained to them while they were in hospital. They gave informed consent to follow up, which was conducted by an independent assessor (JH) either at the hospital or in their own homes according to their preference.

Assessments

Neurological impairment

The presence of sensorimotor symptoms possibly attributable to the SAH or surgery was assessed at three months using the Bond neurophysical scale.³⁰ This widely used clinical instrument assesses the presence of impairments including loss of visual acuity, diplopia, visual field deficits, nystagmus, vertigo, tinnitus, ataxia, locomotor deficits, and dysphasia.

Stressful life events

The revised life changes questionnaire (RLCQ)³¹ requires respondents to indicate whether, over the preceding 12 months, they have experienced any of 74 events relating to work, health, home and family life, personal and social life, and finance. Each of these events is assigned a predetermined number of "life change units", ranging between 0 and 100,

derived from a survey with healthy volunteers. The total score is computed by summing life change units across the 74 items. In the present study, SAH participants were asked to indicate which events had occurred in the 12 month period preceding their haemorrhage, while the healthy volunteers completed the questionnaire with respect to the immediately preceding 12 month period.

In addition, given that the above scale asked only about whether specific events had occurred, patients also completed the 10 item life change scale,³² which asked them to rate in global terms, on a 0–10 scale, the extent of problems they perceived there to have been in each of 10 areas of their life (such as finance, relationships, work) over the preceding 12 months. The maximum score is therefore 100.

Tests of cognitive function

A few cognitive tests were selected on the basis that they tapped functions that have been found in other studies to be most sensitive to residual impairments in SAH patients with good neurological outcomes. Digit span³³ provides indices of attentional span (digits forwards) and working memory (digits backwards); the controlled oral word association test (COWAT)^{34,35} measures verbal fluency, which is influenced by “executive” functioning; and a test of prose recall,³⁶ designed to be formally identical to the logical memory test in the Wechsler memory scale³³ but with four different but equivalently memorable versions to permit repeated testing, yields indices of both immediate and delayed recall of verbal information. In this latter test, participants listen to a short story comprising 25 “ideas” (or facts) and have to recall as many as they can both immediately after hearing it and after a 30 minute delay.

Parallel forms of all these tests were given at each assessment occasion. Verbal fluency and digit span scores were converted to age related percentiles using published norms^{33,35}, where a participant was outside the age range for which such data were available, his or her scores were referenced to the closest available age band. An additional adjustment for years of education was made for the COWAT.³⁵ Age related norms are not available for the test of prose recall; however, we have classified scores as abnormally low if they fell at or below 7/25 for immediate recall or 4/25 for delayed recall, since these were found to be below the 10th percentile in a sample of 55 hypertensive but otherwise healthy people of similar age to the SAH patients tested here (mean age 56.9, range 35–69). These cut offs are commensurate with 10th percentile scores for 45–54 year olds on the logical memory test in the revised Wechsler memory scale.³³

The spot the word test from the speed and capacity of language processing test³⁷ was administered once only to give an estimate of premorbid ability; this forced-choice measure (identifying which of two letter strings is a real word) correlates well with other indices of premorbid intelligence quotient (IQ), has unambiguous scoring, and was felt to be potentially less threatening for participants to complete than tests that require unfamiliar words to be read out loud. Since participants were recruited while still unwell, it was considered particularly important to minimise possible sources of stress.

Mood state

Symptoms of anxiety and depression were assessed using the hospital anxiety and depression scale (HADS).³⁸ This brief and widely used screening instrument requires participants to rate their experience of 14 subjective and behavioural symptoms (seven anxiety related and seven depression related) over the preceding week. The maximum score for each subscale is 21 and the clinical cut off is 10/11 (that is, scores of 11+ fall within the clinical range). When participants were willing to complete another measure, the BDI²⁸ was also given since this

is of proven sensitivity in depression and asks specifically about a range of depressive cognitions and other symptoms occurring over the previous two weeks. Scores can range from 0 to 63 and scores of 19 or higher fall outside the normal range.

The revised impact of events scale (RIES)³⁹ was used to give indices of both intrusive thoughts about the SAH and avoidance of reminders or emotional reactions. Participants indicate how often during the past week they have experienced various types of intrusive thoughts or imagery (maximum score of 35) and how often they have engaged in various types of behavioural or cognitive avoidance (maximum score of 40). These are symptoms characteristically reported by patients with post-traumatic stress disorder (PTSD) and the scale serves as a screening (though not a diagnostic) instrument for PTSD. Here, cut offs of 11/12 for intrusions and 13/14 for avoidance have been used to indicate abnormal scores since these are 1 SD above the mean scored by a normative sample and within the range scored by female PTSD sufferers in the original validation study.³⁹

Social participation

The brain injury community rehabilitation outcome-39 (BICRO-39) scales⁴⁰ measure the impact of brain injury on domestic, social, and psychological functioning in patients living in the community and have been validated in a sample of 240 patients with brain injury of mixed aetiologies. Respondents rate their current levels of independence and frequency of engagement in various aspects of social functioning, as well as aspects of psychological wellbeing that overlap with but are not identical with anxiety and depression. Based on evidence of good patient-care giver agreement, test-retest reliability, sensitivity to the effects of brain injury, and evidence of construct validity, the following six (out of eight) scales were selected for use here:

- *Personal care*: Independence in basic self care activities (such as using the toilet) and mobility or access to facilities within the home (0 = “with no help” to 5 = “can’t do at all”).
- *Mobility*: Independence in more physically demanding tasks (such as doing laundry, shopping; 0 = “with no help” to 5 = “can’t do at all”).
- *Self-Organisation*: Independence with structuring personal and domestic activities (such as paying bills, managing appointments; 0 = “with no help” to 5 = “can’t do at all”).
- *Socialising*: Frequency of contact with people other than immediate family (such as friends, colleagues; 0 = “never” to 5 = “daily”).
- *Productive employment*: Frequency of engagement in education, work or childcare (0 = “not at all” to 5 = “several hours a day”).
- *Psychological wellbeing*: Frequency of feeling impatient with self, bored, lonely, worn out, hopeless about the future, and angry with others (0 = “never” to 5 = “almost always”).

In addition to rating their current functioning, the SAH participants retrospectively rated their functioning in these domains before their illness. Thus, their scores at follow up could be compared with both those of the control participants and their own premorbid scores.

Statistical analyses

To test the prediction that in general SAH patients would have more severe problems than comparable healthy adults, multivariate analyses of variance (MANOVA) were used to compare the scores of the SAH group, firstly at three months and secondly at nine months, with the reference scores of the control group. On each occasion, separate MANOVA were performed on “families” of measures comprising the two HADS subscales and the six BICRO subscales.

Table 1 Cognitive, mood, and psychosocial function data for patients with subarachnoid haemorrhage (SAH) at three and nine months and for matched controls

	Controls			SAH group at three months			SAH group at nine months		
	No	Mean (SD)	Percentage in clinical range* or <10th percentile†	No	Mean (SD)	Percentage in clinical range* or <10th percentile†	No	Mean (SD)	Percentage in clinical range* or <10th percentile†
Cognitive measures									
Verbal fluency‡				42	48.9 (33.2)	16.7	44	56.0 (32.7)	11.6
Prose recall—immediate (0–25)				44	8.5 (3.1)	36.4	44	9.3 (3.9)	34.1
Prose recall—delayed (0–25)				44	6.9 (3.7)	29.5	44	8.3 (4.0)	18.2
Digit span forwards‡				48	67.7 (30.2)	8.1	45	65.9 (30.6)	4.4
Digit span backwards‡				48	43.0 (30.7)	23.0	45	54.0 (30.4)	8.9
Mood measures									
HADS anxiety (0–21)	52	5.3 (3.0)	5.7	50	7.2 (4.0)	16.0	47	7.3 (4.2)	17.0
HADS depression (0–21)	52	3.8 (3.5)	3.8	50	6.0 (3.8)	14.0	47	5.0 (3.6)	8.5
RIES—intrusions (0–35)				47	11.8 (8.5)	51.1	47	8.5 (7.0)	25.5
RIES—avoidance (0–40)				47	11.7 (9.1)	38.3	47	6.9 (6.7)	17.0
BDI (0–63)				44	9.6 (6.2)	9.1	44	9.2 (6.9)	11.4
Participation (BICRO-39)									
Personal care (0–6)	52	0.0 (0.2)		51	0.1 (0.7)	5.9	48	0.0 (0.0)	2.1
Mobility (0–5)	52	0.2 (0.3)		51	1.3 (1.5)	51.0	48	0.7 (1.1)	35.4
Self organisation (0–5)	52	0.1 (0.4)		51	1.2 (1.5)	51.0	48	0.8 (1.3)	50.0
Socialising (0–5)	52	2.9 (0.7)		51	2.6 (0.8)	5.9	48	2.9 (0.8)	9.3
Employment (0–5)	52	3.0 (0.8)		51	4.3 (1.0)	72.5	48	4.0 (0.9)	56.2
Psychological wellbeing (0–5)	52	1.5 (0.7)		51	1.9 (0.9)	15.7	48	1.8 (0.8)	12.5

*Cut offs for “abnormality” as follows: hospital anxiety and depression scale (HADS) anxiety and depression 10/11, revised impact of events scale (RIES) intrusions 11/12, RIES avoidance 13/14, Beck depression inventory (BDI) 18/19, prose recall (immediate) 7/8, prose recall (delayed) 4/5. †Verbal fluency and digit span scores were evaluated against published norms. Brain injury community rehabilitation outcome-39 (BICRO-39) scores of SAH participants were evaluated against control group distribution. ‡Verbal fluency and digit span scores are presented as age adjusted percentiles.

Within the SAH group, repeated measures MANOVA evaluated change in the BICRO scales from preinjury to the three and nine months' follow ups. Three further repeated measures MANOVA were used to determine whether there was significant recovery from three to nine months on cognitive measures, the mood measures, and the BICRO scales. Samples for these analyses were slightly depleted because several participants had some missing data.

In all of these MANOVA, if a significant overall effect was found then univariate statistics are reported for the individual component measures; in these post hoc analyses, Bonferroni corrections for multiple comparisons were made within each family of measures.

Multiple regression was used to explore the relations between a number of predictor variables and psychosocial outcomes, selected on the basis of the findings of the MANOVA.

RESULTS

Participants

Both SAH and control groups comprised 35 women and 17 men. SAH participants were aged from 27 to 82 years (mean age 46.9 (10.4)) and controls from 26 to 74 years (mean (SD) age 46.7 (10.7)). Occupational status covered a wide range: 11 in each group were not in paid employment; 10 of the SAH and 8 of the controls were in unskilled or semiskilled occupations; 19 and 18, respectively, were in skilled manual or clerical work; and 12 and 15, respectively, were in professional positions. The groups were thus very comparable, reflecting the close individual matching.

Of the SAH patients, 47 had their aneurysms clipped, four had them coiled or wrapped, and one was managed conservatively. Forty four participants had a GOS score of 5 and the remainder scored 4. Fifty one participants were successfully contacted and assessed at three months after hospital discharge and 48 at nine months.

Spot the word scores were missing for nine participants and ranged between 22 and 59 (46.9 (6.9), mid-average range) for the remaining 45. Scores on the Bond neurophysical scale at the first assessment indicated that 23.5% had impaired visual

acuity, 8% had a visual field deficit, 6% had diplopia, 15.7% had tinnitus, 27.5% had dysphasia, and 12% had vertigo. None suffered from nystagmus, ataxia, or locomotory deficits. In all, 61% of the sample presented with at least one of the above symptoms, though in most cases they were mild, and some—such as impairments of visual acuity—could not be unambiguously attributed to the SAH.

Eight SAH participants reported a prior history of treatment for psychiatric or emotional problems; two of these and another two participants also reported prior drug or alcohol problems. Very few patients reported significant histories of physical ill health, though one had had a head injury necessitating hospital admission and one had suffered a previous cerebrovascular accident. These data were not gathered for control participants.

Research questions

Analyses related to the research questions specified in the introduction are presented in corresponding order below.

1. Prevalence of cognitive and psychosocial dysfunction over nine months post-SAH

Table 1 shows means and standard deviations for the measures of cognitive functioning, mood, and participation in the SAH participants at three and nine months. Control group scores on the HADS and BICRO, measured once only, are also shown. Prevalence of abnormality is presented for each measure, with abnormality operationally defined as above clinical cut offs (for mood measures), below the 10th percentile compared with published normative data (cognitive measures), or above the 90th percentile of the matched control group (BICRO scales).

Cognitive functioning

The scores of SAH patients on these variables were approximately normally distributed. Control participants were not tested; rather, patients' scores were compared with existing normative data. At three months over 29% of SAH participants scored below the 10th percentile on the tests of immediate and delayed prose recall and 23% did so on backwards digit span.

In contrast there was no indication of impairments of forwards digit span and only a slightly increased rate of impairment (16.7%) on verbal fluency. At nine months the only measures for which there was evidence of abnormally low performance were the immediate and delayed prose recall tests.

For the 41 SAH patients with complete data on all measures, repeated measures MANOVA showed a significant improvement from three to nine months ($F_{3,36} = 3.3$, $p < 0.02$). Univariate analysis of variance on the five tests individually, using data from all participants who had completed each test on both occasions and with Bonferroni correction reducing the probability level for significance to 0.01, showed significant improvements on verbal fluency ($F_{1,40} = 6.5$, $p = 0.01$) and delayed prose recall ($F_{1,40} = 7.5$, $p < 0.01$) and a trend for reversed digit span ($F_{1,40} = 6.1$, $p = 0.02$) but no change in either immediate prose recall or digit span forwards ($F_{1,40} < 2.3$, NS, in both cases).

Mood state

All of the mood measures were reasonably normally distributed. As table 1 shows, high proportions of SAH participants scored in the clinical range on the two RIES subscales (intrusive thoughts and avoidance) at both assessment points. Strikingly, 28 (60%) of the 47 patients who completed the RIES at three months scored in the clinical range on at least one of the two symptoms, while 14 (30%) did so for both. At nine months, the incidence of both types of symptom had fallen, with 30% of respondents showing at least one symptom and 15% showing both. Smaller but still quite substantial proportions of participants scored in the clinical range on HADS anxiety (16%) and depression (14%) at three months; this showed virtually no change by nine months for anxiety (17%) and only a slight reduction in depression (to 8.5%). BDI scores remained stable, with approximately 10% scoring in the clinical range on both occasions.

MANOVA comparing the HADS scores of the SAH patients on the two occasions separately with those of the control group showed significantly increased scores in the SAH group at three months ($F_{2,48} = 4.5$, $p < 0.02$) and a marginally significant trend in the same direction at nine months ($F_{2,45} = 3.0$, $p = 0.06$). Univariate comparisons, with significance levels adjusted to $p < 0.025$, indicated that both anxiety and depression were higher in the SAH group at three months, while this was true for anxiety but not depression at nine months.

A repeated measures MANOVA on the two HADS and two RIES subscales examined change shown by SAH participants from three to nine months. BDI scores were excluded from this analysis because of a relatively large amount of missing data. This showed a general improvement in mood state ($F_{4,39} = 5.0$, $p < 0.005$). Univariate analyses of variance, with Bonferroni correction of the significance level to $p < 0.01$, detected significant recovery on both of the RIES subscales but on neither of the HADS subscales or on the BDI.

Participation: the BICRO-39

As in the original validation study,⁴⁰ the distributions for personal care, mobility, self organisation, and productive employment subscales were all skewed; however, both univariate and multivariate analyses of variance are relatively robust with respect to skewness and so the statistical approach is the same as for the other variables.

It can be seen from table 1 that at both three and nine months over half of the SAH participants scored abnormally (above the 90th percentile of the control participants, indicating low activity or participation) on self organisation and productive employment. This was also true for mobility at three months and over a third continued to score abnormally at nine months.

BICRO subscale scores were significantly higher in the SAH than in the control group at both three months ($F_{6,45} = 15.6$, $p < 0.001$) and nine months ($F_{6,42} = 10.0$, $p < 0.001$). Post hoc univariate analyses of variance, with the significance level adjusted to $p < 0.008$ to correct for multiple comparisons, showed significant impairments in the SAH group relative to the control group on mobility, self organisation, and productive employment on both occasions. There were no between group differences for personal care, socialising, or psychological wellbeing.

Table 2 shows patients' BICRO scores compared with their own preillness ratings.

It is first of all notable that, although patients' retrospective ratings of premorbid personal care, mobility, and self organisation were commensurate with control group ratings, they did report slightly better psychological wellbeing than the control group ($F_{1,51} = 6.4$, $p < 0.02$). Consequently, although patients' scores at follow up were not worse than those of the control group, comparison with their own ratings of premorbid mood suggests higher rates of deterioration. Ratings of pre-SAH productive employment indicated that as a group the patients had spent fewer hours in active work than their counterparts. However, even compared with their own ratings of preillness employment, a very high proportion of the SAH group (60%) had failed to resume normal levels by three months and 40% were still scoring at or above the 90th percentile for the group premorbidly. Finally, their ratings of premorbid socialising were indicative of higher social activity than reported by controls ($F_{1,51} = 9.4$, $p < 0.003$), so that the prevalence of abnormally high scores (low activity) seen at nine months is slightly higher than when the comparison was with the control group.

MANOVA comparing follow up with premorbid scores showed an overall main effect of time ($F_{12,36} = 7.0$, $p < 0.001$). Post hoc univariate contrasts of three and nine month scores on individual subscales against pre-SAH ratings, with Bonferroni adjustment of the significance level to $p < 0.004$, detected significant deteriorations from pre-SAH to both three and nine months on productive employment, mobility, psychological wellbeing, and self organisation ($F_{1,47} > 12$, $p < 0.001$ in all cases). Personal care, however, did not decline ($F_{1,47} < 1$, NS,

Table 2 BICRO scores for SAH participants, rated retrospectively for preinjury and at three and nine months postinjury

	Preinjury (n = 52)	Three months postinjury (n = 51)			Nine months postinjury (n = 48)		
	Mean (SD)	Mean (SD)	Scoring above preinjury 90th percentile (%)	Three months v preinjury†	Mean (SD)	Scoring above preinjury 90th percentile (%)	Nine months v preinjury†
Personal care	0.0 (0.0)	0.1 (0.7)	5.9	NS	0.0 (0.0)	2.1	NS
Mobility	0.1 (0.3)	1.3 (1.5)	51.0	*	0.7 (1.1)	35.4	*
Self organisation	0.2 (0.5)	1.2 (1.5)	39.2	*	0.8 (1.3)	18.7	*
Socialising	2.4 (0.8)	2.6 (0.8)	13.7	NS	2.9 (0.8)	22.9	NS
Employment	3.5 (0.9)	4.3 (1.0)	60.8	*	4.0 (0.9)	43.7	*
Psychological	1.1 (0.7)	1.9 (0.9)	39.2	*	1.8 (0.8)	37.5	*

* $p < 0.008$; †Results of univariate analyses of variance for socialising and psychological wellbeing, and Wilcoxon signed rank tests for all other scales.

for both three and nine month comparisons), while socialising scores did not differ from premorbid levels at three months ($F_{1,47} = 3.7$, NS) but were worse (that is, there was less social contact with others) by nine months ($F_{1,47} = 9.9$, $p < 0.004$).

Comparison of scores at three and nine months indicated some overall recovery ($F_{6,42} = 3.1$, $p < 0.02$); however, univariate analyses with the significance level adjusted to 0.008 found only one individual scale (mobility) to show significant improvement ($F_{1,47} = 7.1$, $p = 0.01$).

2. Life stress in year preceding SAH

The two measures of prior life stress, referring to the year before surgery in the SAH group and the 12 month period preceding the assessment in the control group, were both positively skewed and consequently correlational analyses have used non-parametric statistics.

The two scales were uncorrelated with each other (Spearman's $r_s = 0.21$, NS). SAH participants' life events scores on the RLCQ were non-significantly higher than those of the matched control participants (mean (SD) 202.6 (153.9) and 175.6 (114), respectively) $F_{1,51} = 1.2$, NS). However, the SAH group did show a trend towards higher scores than the control group on the life change scale (LCS), which indicates perceived stress rather than the occurrence or non-occurrence of specific events (SAH 25.3 (17.8), controls 18.7 (16.9), $F_{1,51} = 3.7$, $p < 0.06$).

Patients with prior mental health problems ($n = 8$) had higher LCS scores than the other SAH participants (37.3 (8.2) v 23.1 (18.3), Mann-Whitney U test, $Z = -2.4$, $p < 0.01$) but did not differ on RLCQ scores (190.0 (135.9) v 269.6 (230.4), Mann-Whitney U test, $Z = -1.1$, NS).

Given the wide age range of the sample, we explored the possibility that stressors may interact with age to trigger a SAH. Within the SAH and control groups separately, age was found to correlate negatively with LCS scores (Spearman's $r_s = -0.36$, $p < 0.01$ and -0.31 , $p < 0.05$, respectively)—that is, older participants perceived themselves to have been under less stress. There was no relation, however, between age and RLCQ ("objective" stress) scores in either group. We then subdivided the two groups on median age (46 or under versus 47 or older) and conducted a repeated measures analyses of variance with age as a between subjects factor and group (SAH versus control) as the repeated measure. There was no group $\times$ age interaction for either RLCQ or LCS scores ($F_{1,50} < 1$, NS in both cases).

3. Predictors of adverse psychosocial outcomes

The relatively small sample size of this study meant that it had sufficient power to explore relations between only a limited

number of nine month outcome variables and potential predictors. Within the functional outcomes, three were of particular interest because they showed a high level of sensitivity to adverse change: productive employment, mobility, and self organisation. As expected, given the orthogonality of these scales in the original validation study,⁴⁰ scores in the present sample were largely independent of one another, the only significant correlation being between self organisation and mobility (Spearman's $r_s = 0.46$, $p < 0.001$). They were therefore considered separately.

Within the mood related outcomes, however, the intercorrelations were much stronger. The two RIES subscales and the two HADS subscales showed Pearson's correlations with one another ranging between 0.56 (HADS depression with RIES intrusions) and 0.76 (RIES intrusions with RIES avoidance); all were significant beyond $p < 0.001$. BDI data were incomplete and so were excluded from these analyses. Since these indices were so closely related, a total "mood disturbance" score was computed by summing scores on the four subscales.

Nine predictors were selected as follows (italics indicate variable names used hereafter):

- Two demographic variables: (a) *age* and (b) *sex*;
- Three indicators of clinical impairment: (a) *GOS score* (4 or 5); (b) *dysphasia* at three months (present or absent); (c) raw score on immediate *prose recall* at three months;
- Four indicators of health and life stress before the SAH: (a) *physical health* in the preceding 12 months, rated from 1 (good) to 4 (major problems); (b) history of any treatment for *mental health* problems (yes or no); (c) *RLCQ scores* (objective stressors) for preceding year; (d) *LCS scores* (subjective stress) for preceding year.

Other predictors that would have been of interest were excluded either because there was insufficient variation within the sample to make meaningful comparisons or because a related index was selected in preference (for example, immediate prose recall was taken as a marker of cognitive impairment at three months because it was more likely than other cognitive indices to be impaired).

Table 3 shows the individual relations between each of the nine predictors and each of the four outcome variables, with non-parametric correlations used for continuous variables (age, physical health, prose recall, RLCQ, and LCS) and Mann-Whitney U tests for dichotomous variables (sex, dysphasia, GOS scores, and mental health).

Given the relatively large number of independent variables, the preferred statistical approach for exploring their predictive utility is multiple regression. All nine predictor variables were

Table 3 Relations between background (clinical, demographic, pre-SA) data and selected psychosocial outcome measures

	No†	BICRO-39 scales				Mood disturbance (HADS + RIES)†			
		Productive employment	Mobility	Self organisation					
Demographic characteristics									
Age	48	$r = 0.20$	NS	$r = 0.12$	NS	$r = 0.15$	NS	$r = -0.08$	NS
Sex	48	$Z = -0.01$	NS	$Z = -2.22$	*	$Z = -0.33$	NS	$Z = -0.67$	NS
Clinical presentation									
GOS score	48	$Z = -0.97$	NS	$Z = -2.11$	*	$Z = -1.60$	NS	$Z = -0.57$	NS
Dysphasia at 3 months	48	$Z = -1.45$	NS	$Z = -2.01$	*	$Z = -2.54$	**	$Z = -2.42$	*
Immediate prose recall at 3 months	43	$r = -0.32$	*	$r = -0.27$	NS	$r = -0.46$	***	$r = -0.35$	*
History									
Life stress (objective)—RLCQ	48	$r = -0.06$	NS	$r = -0.14$	NS	$r = -0.36$	**	$r = 0.07$	NS
Life stress (subjective)—LCU	48	$r = -0.07$	NS	$r = 0.03$	NS	$r = 0.06$	NS	$r = 0.21$	NS
Health problems in past year	48	$r = 0.36$	**	$r = 0.18$	NS	$r = 0.05$	NS	$r = 0.24$	NS
Mental health treatment (ever)	48	$Z = -0.34$	NS	$Z = -0.03$	NS	$Z = -0.19$	NS	$Z = -2.93$	***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.005$ (all tests two tailed); all tests non-parametric (Spearman's r_s or Mann-Whitney U tests). †These numbers refer to correlations with BICRO scales. Sample size is reduced by one for correlations with mood disturbance. GOS, Glasgow outcome scale; LCU, life change units; RLCQ, revised life changes questionnaire.

thus entered simultaneously into a regression on each of the four outcome variables. The size of the present sample with complete data on all predictors was 42 or 43 for each outcome variable; this is slightly below the minimum sample size recommended for regression analysis ($40 + p$, where p is the number of predictor variables)⁴¹ and so the results must be treated somewhat cautiously.

The nine predictors jointly accounted for 22% of the variance in BICRO self organisation ($R = 0.62$, adjusted $R^2 = 0.22$, $F_{9,33} = 1.9$, $p < 0.05$); prose recall and RLCQ scores emerged as the strongest individual predictors accounting, respectively (and uniquely), for 11% of the variance ($B = -1.0$, $p = 0.02$) and 10% ($B = 0.02$, $p = 0.03$). For BICRO mobility, adjusted R^2 was 0.20 ($R = 0.61$, $F_{9,33} = 2.17$, $p = 0.05$); however, no individual predictor accounted for a significant unique portion of the variance ($< 5\%$ each). Only 13% of the variance in BICRO productive employment was predicted and this fell short of significance ($R = 0.55$, adjusted $R^2 = 0.13$, $F_{9,33} = 1.69$, NS).

Finally, mood disturbance was the outcome most strongly predicted by this set of variables ($R = 0.75$, adjusted $R^2 = 0.45$, $F_{9,32} = 4.7$, $p < 0.001$). Four predictors made significant unique contributions to the variance: mental health (15%; $B = 22.60$, $p < 0.002$); physical health (12%; $B = 9.98$, $p < 0.01$); dysphasia (8%; $B = 15.6$, $p < 0.05$); and prose recall (5%; $B = 1.6$, $p = 0.05$).

4. Relations between emotional and functional outcomes

To explore whether failures to resume normal or premorbid patterns of domestic and social activity might be related to persistent mood disturbance, nine month scores on three of the BICRO scales (mobility, self organisation, and productive employment) were correlated with nine month mood disturbance (HADS + RIES scores). The only significant association was between mood disturbance and self organisation (Spearman's $r_s = 0.33$, $p < 0.05$).

DISCUSSION

Prevalence of cognitive and psychosocial dysfunction over nine months post-SAH

This prospective study has confirmed a high incidence of poor psychosocial functioning in people who have made a good neurological recovery from SAH. Unlike any other previous study of which we are aware, an individually matched neurologically healthy control group was assessed on a number of the key outcome variables, enabling us to conclude with considerable confidence that the increased levels of mood disturbance and the reduced levels of independence and participation seen after hospital discharge do not simply reflect age, sex, or social class.

Clinically significant levels of anxiety were reported both three and nine months postillness by about one patient in six, almost three times the rate seen in the control group. The rate of depression was also two to three times as high in the SAH group at both points. Comparison of total HADS (anxiety + depression) scores with recently published sex related norms⁴² indicates that 23% of patients scored above the 90th percentile at three months and 21% at nine months. Consistent with the comparison with controls, then, these figures indicate that the rate of mood disturbance is approximately doubled after SAH and declines little over nine months.

Even more striking was the high incidence of two symptoms seen in PTSD: intrusive thoughts about the illness or associated hospitalisation and avoidance of reminders of it. At three months, 60% of patients showed at least one of these symptoms at a level well within the range seen in PTSD sufferers and 30% showed both. These rates had halved by nine months, comparable with the pattern seen over the first year after other life threatening traumas⁴³ but nevertheless

remaining very high. Taken together with the high incidence of anxiety and depression, and with the fact that a diagnosis of PTSD under *Diagnostic and statistical manual of mental disorders*, fourth edition, requires symptoms of intrusive thoughts, avoidance, and increased arousal to have persisted for just one month, these data raise the possibility that a substantial number of SAH patients might meet diagnostic criteria for the disorder nine months after surgery. This is important, since it is by no means a well recognised problem after SAH: an extensive literature search found only one single case study.²⁶ However, the exploratory methods used here relied on participants' self report of symptoms rather than formal diagnostic assessment procedures. We did not aim to determine the prevalence of specific psychiatric diagnoses and measured only a subset of the symptoms that, with others, characterise various forms of anxiety and depressive disorder (including PTSD). Nevertheless, these results do show a need to be sensitive to a range of possible adverse psychological symptoms that may interfere with other aspects of recovery and in some cases may be indicative of significant and treatable psychiatric disturbances.

With respect to impairments of cognition, over 36% of patients scored abnormally low on immediate prose recall, 29.5% on delayed prose recall, and 23% on reversed digit span; these figures are all between two and four times the rate expected in adults aged between 35 and 69 and so it is unlikely that the findings are an artefact of the relatively high mean age of the present SAH sample. There was little or no improvement in immediate prose recall by nine months, with close to a third of participants continuing to score below the 10th percentile; however, delayed recall and reversed digit span did improve somewhat, the latter to normal levels. Conflicting with findings reported elsewhere (for example, Soneson *et al*¹⁰), neither forwards digit span nor verbal fluency showed unusually high rates of impairment at either follow up point. This may reflect the fact that we adjusted scores for age and, in the case of verbal fluency, for sex and educational level; studies that have not made such adjustments may overestimate the frequency or level of impairments. Consistent with this hypothesis, when we compared unadjusted scores of the present sample with norms for people aged between 50 and 54,⁴⁴ the numbers scoring below the 10th percentile were higher: 21% at three months and 19% at nine. In any event, overall the present data suggest that SAH is associated with subtle cognitive impairments persisting to nine months in perhaps 10 to 20% of patients. The possibility cannot of course be excluded that a higher proportion of patients might have shown impairment on more sensitive indices of cognitive functioning than those administered within our brief screening test battery.

The BICRO-39⁴⁰ indexed functioning in various aspects of daily life and, although there was no indication of impairments relative to the control group on personal care activities, socialising, or psychological wellbeing, at three months just over half of the SAH patients were substantially more dependent on others for domestic activities with a strong mobility requirement ("mobility") and for organisational activities ("self organisation", for example, daily event planning and scheduling, bill payment, correspondence). There was no improvement in self organisation by nine months and only a modest improvement in mobility, with over a third continuing to score abnormally. However, the most dramatic difference between the groups was on levels of productive employment (paid and voluntary work, education or training, and childcare): almost three quarters of SAH participants scored below the 10th percentile of the control group at three months and over half continued to do so at nine months.

BICRO scores at follow up were also compared with patients' own retrospective ratings of their preillness functioning, which differed on some subscales from those of the control group. Specifically, the ratings indicated that their

preillness psychological wellbeing was better than that of the controls, their socialising was higher, and their engagement in productive employment was lower. These differences may be real but may also reflect distortions in recall by the SAH patients. Nevertheless, the overall pattern of deterioration indicated by comparisons of preillness with postillness scores was consistent with that inferred from comparison with control data, manifesting in significantly reduced independence in mobility, self organisation, and productive employment. Although psychological wellbeing also appeared to be significantly worse than it had been before the illness, retrospective ratings in this domain are likely to be particularly prone to bias and in the absence of significant differences from control group scores this finding should be viewed cautiously.

Life stress in the year preceding SAH

SAH patients did not indicate an unusually high frequency of objectively defined stressful life events on the RLCQ in the year preceding their illness, though there was a trend for their subjective ratings of global life change on the LCS to exceed those of the control group. The lack of correlation between these two indices indicates that subjective ratings were strongly influenced by factors other than the occurrence of specific events listed in the RLCQ. In part this may reflect limits to the sensitivity of the RLCQ: not every possible stressful life event is included in the list and there is considerable individual variability in the circumstances and stress associated with any specific event. It is also likely, however, that the emotional impact of surviving SAH, or the desire to find explanations for it, influenced patients' retrospective ratings of prior events. Such recall biases have been reported elsewhere^{45, 46}; for example, Raphael and Cloitre⁴⁶ found that although patients with chronic pain were unimpaired in recalling events that had been recorded prospectively over the preceding year, their subjective appraisal of those events was significantly related to current mood. There is additional support for this within the present study, in that total HADS score at three months (when the life events measures were administered) did not correlate with the RLCQ but was significantly associated with LCS scores ($r = 0.37$, $p < 0.01$). Similarly, SAH patients with prior mental health problems gave increased LCS ratings but did not differ from the other patients on the RLCQ.

The lack of a difference between SAH and control groups here on RLCQ scores appears to contradict the findings of Ogden *et al.*²⁴ who used a precursor of the RLCQ (the social readjustment rating scale⁴⁷). This may reflect differences between the two versions of the scale but is perhaps more likely to relate to the comparison groups used. Ogden *et al.*²⁴ did not match their orthopaedic control participants individually and there may consequently have been demographically relevant differences between groups. Sex ratio did in fact differ and limited information was given about other potentially relevant variables such as occupational status.

As far as we can determine from the present data, then, objectively measured stressful life events did not constitute a risk factor for SAH in our sample. Interestingly, the scores of participants with prior mental health problems were not significantly increased. Although older participants reported fewer such events than younger participants, no increased risk of SAH following high life stress was detected in either age group. However, the sample size lacked the power to show small effects and future research using larger samples would be valuable.

Predictors of adverse psychosocial outcomes

Four indices of outcome at nine months were selected for exploration. A combined "mood disturbance" variable was computed by summing the strongly intercorrelated HADS and RIES subscale scores; the other three were the BICRO

subscales that had shown the highest rates of abnormality in the SAH group—namely, mobility, self organisation, and productive employment. The nine predictor variables entered into regressions on each of the four outcomes comprised demographic factors (age and sex), clinical outcome or impairment (GOS score, and dysphasia and prose recall at three months), and premorbid factors (RLCQ and LCS indices of life stress, physical health in the previous year, and a history of mental health problems).

Productive employment was not significantly predicted by this combination of variables. They did, however, jointly account for 22% of the variance in self organisation, 20% of the variance in mobility, and a striking 45% of the variance in mood disturbance. Analysis of the unique relations (part correlations) between each of the nine predictors and the outcomes showed that while no individual predictors were significantly and uniquely related to mobility, self organisation was independently associated with prose recall, possibly reflecting the reliance of organisational activities on efficient cognitive functioning, and (negatively) with pre-SAH life stress (RLCQ). This latter association, although unexpected, may reflect necessity; for example, the absence or loss of a partner may be associated with increased life stress and with a need to be more self reliant post-SAH.

Prior mental health on its own explained 15% of the variance in mood disturbance, physical health a further 12%, and dysphasia and prose recall 8% and 5%, respectively. The relation with prose recall is weakest but also most ambiguous, since it can either contribute to or be a consequence of low mood. Overall, these data suggest that, clinically, patients at particular risk of prolonged adverse emotional reactions can be identified at an early stage on the basis of their history and presence of dysphasic problems. The absence of any clear predictors or correlates of reduced employment, the most frequent adverse outcome in the present sample, is intriguing since it suggests that there must be influential sequelae of SAH that have not been tapped by any of the predictors explored here. One possibility was suggested by frequent anecdotal reports of headaches and fatigue. We systematically asked about these at nine months and found high rates of both (64.6% and 81.2%, respectively). Although they did not predict employment status, the likelihood of detecting associations may have been limited by the insensitivity of the ratings we gathered (present or absent rather than severity). Future research might usefully include more sensitive and validated indices of these symptoms both to document their occurrence more accurately and to determine whether they are associated with adverse psychosocial outcomes. Another contribution to the change in employment related activities emerged from the interviews and pertains to the pivotal nature of a life threatening illness in lifestyle decision making: several patients observed that their illness had prompted them to reappraise and substantially adjust their work and personal priorities so that they had made a constructive decision not to resume preillness patterns of activity. Systematic investigation of this rather more positive interpretation of apparently adverse change would be interesting both in this population and in patients who have survived other serious accidents or illnesses, as it clearly challenges the view that the desirable clinical outcome is typically a resumption of "life as normal".

Life stress in the year preceding SAH, as indexed by the RLCQ and LCS, failed to contribute significantly to prediction of any outcome variable. These data are therefore not consistent with the speculative hypothesis that the association between SAH and poor psychosocial functioning may reflect a shared relation with premorbid stress.

Relation between emotional and functional outcomes

BICRO self organisation at nine months was significantly, though weakly, correlated with total mood disturbance

($r = 0.33$), such that patients who were more dependent on help from others tended to have lower mood. The causal relation is ambiguous, as it is equally plausible that low mood may reduce effort or that decreased ability to function independently would have a negative impact on mood, perhaps through a reduction in self esteem or activity levels. Alternatively the relation may be mediated to some degree by shared associations with a third factor such as subtle brain dysfunction or persisting fatigue. It is notable that a similar association between postinjury emotional disturbance and functional limitations has recently been reported in a very large scale prospective study of more than a thousand trauma patients.⁴⁸ However, neither mobility nor productive employment scores in the present patient group were related to mood disturbance; thus, these data fail to substantiate the view that reductions in independence and participation after SAH are largely attributable to low mood.

Conclusions and implications

This study has found that a substantial proportion of patients who have made a good neurological recovery after surgery for aneurysmal SAH present with protracted disturbances of mood, particularly symptoms characteristic of post-traumatic stress, increased dependence on others for help with domestic and organisational activities, and reduced levels of productive employment. We are following these patients up for a further nine months (to 18 months postillness) to determine whether and to what extent these problems progressively resolve. However, notwithstanding the degree of further spontaneous recovery that may occur, we suggest that the development, evaluation, and provision of focused interventions from rehabilitation or mental health professionals (such as nurse specialists, occupational therapists, and clinical psychologists) may result in substantial economic benefits as well as improved quality of life for patients in the first year after their illness.

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